Crystallographic Effects in Intergranular Corrosion of an Al-Mg Alloy

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The desire for weightsaving has led to increasing use of aluminum alloys, particularly 5XXX Al-Mg alloys, for automotive applications. It is well known that alloys with Mg contents above 3% can be susceptible to stress corrosion cracking as a result of “sensitization”, which is due to the precipitation of an Mg-rich β-phase at grain boundaries. The aim of the present study was to determine the effect of microstructure on the degree of sensitization, particularly the role of grain boundary misorientation.

Experimental Method

A model alloy based on the commercial alloy 5754 was provided by Alcan International (Al-4.0 Mg-0.5 Cu). It was solution treated for 3 mins at 550ºC followed by a fast air-quench, then sensitized for 1000 hours at 120ºC. After metallographic polishing, chemical cleaning in 5% NaOH for 1 minute was followed by desmutting in concentrated nitric acid for 30 s. Intergranular attack was achieved by etching in 10% phosphoric acid at 60ºC. The surface was then marked with a hardness indenter in order to compare the attacked area with the replica.

The crystallographic orientation of the grains on the sample was determined by collecting electron back-scattered diffraction (EBSD) patterns using a JEOL 840 scanning electron microscope (SEM).

The depth of grain boundary attack was then determined by making an epoxy replica of the surface (Epofix) using a vacuum-based method. After the resin was cured, the aluminum was dissolved in 10 g/l NaOH for 10 hours, leaving an epoxy replica of the attacked grain boundary network. The replica was gold-coated before being examined in a Wyko surface profiler.

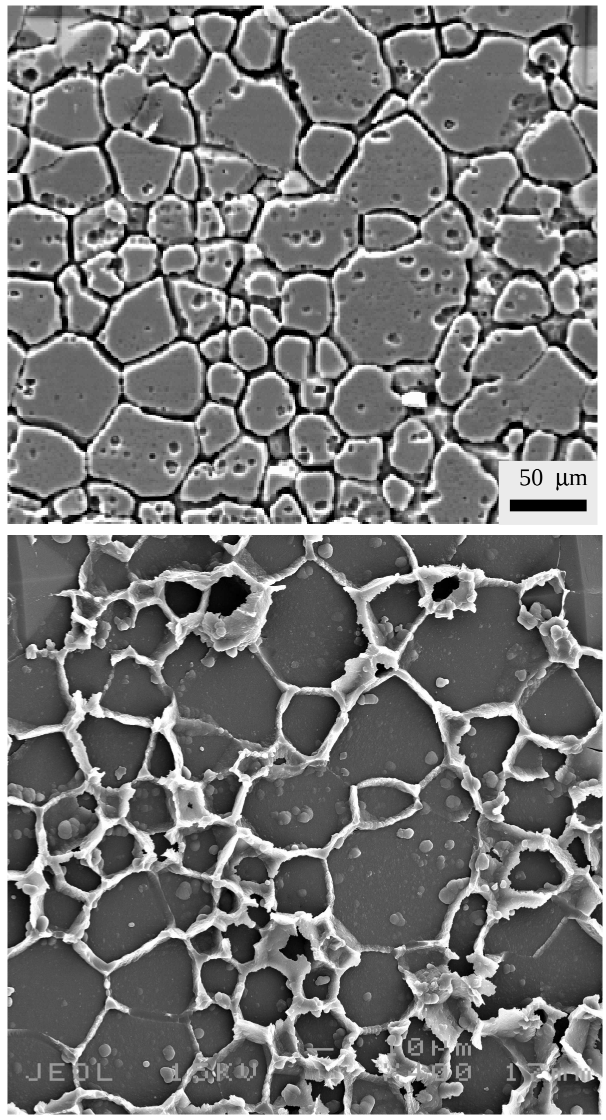

Figure 1 Grain boundary attack of sensitized Al-4.0Mg-0.5Cu after exposure to 10% phosphoric acid at 60°C for 10 minutes. An SEM picture of the attacked surface is compared with the epoxy replica of the same region.

Results and Discussion

Figure 1 shows an SEM image of a sample that has been treated in phosphoric acid for 10 minutes together with the epoxy replica. There is heavy attack of the grain boundaries, but the extent of attack varies from boundary to boundary. Analysis of the depth of attack as a function of misorientation angle determined from the EBSD pattern from the surface demonstrates that for low grain boundary misorientations, the attack is less severe (Figure 2). The results are being compared with an investigation of the degree of precipitation and segregation of Mg-rich phases at grain boundaries.

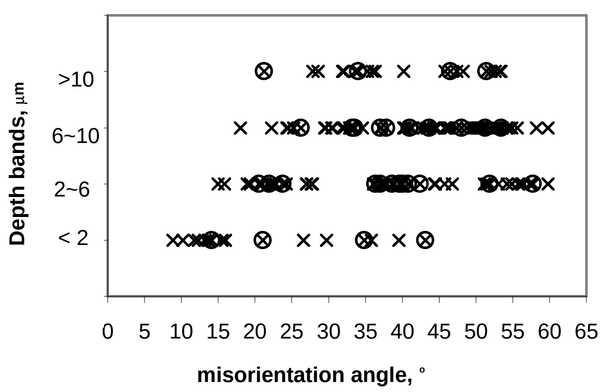

Figure 2. Depth of attack as a function of grain boundary misorientation angle.

Conclusion

The depth of intergranular attack on a sensitized Al-Mg alloy varies with grain boundary character, increasing with increasing misorientation angle.

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